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Water Protection Areas of the Rheingau

1. Introduction

About 95 % of potable water in Hesse is drawn from groundwater. Groundwater is accepted as the best source for potable water since it is free from potential health threats (Deutscher Verein von Gas- und Wasserfachmännern e.V. 1975). The quality of groundwater is severely impaired by contaminants (such as oil, nitrate, pesticide residues), which can only be partially removed by technological means. In order to protect the groundwater and safeguard a clean communal potable water supply, legislative authorities have delineated water protection areas. According to the water protection area act, all land management constraints and restrictions for industrial and agricultural land use are designed to minimize the threat of groundwater contamination.

However, uniform regulations can lead to difficult situations when rigidly applied to the heterogeneity of agriculturally and viticulturally used land. In this case, the aim to protect groundwater quality may conflict with the production of high-quality agricultural products. In the Rheingau, it is the wine-growers that are especially affected by this conflict. In an attempt to alleviate the problem, winegrowers and water works companies have formed a voluntary cooperation “wine-growing and groundwater protection”. This provides the means for producing high quality wines while at the same time affording best possible protection of groundwater by introducing site adjusted management measures.

2. Water protection areas of the Rheingau

The cultural landscape of the Rheingau region has developed over many centuries. Today this appealing landscape, close to the Rhein-Main conurbation is a favored residential area. As a result, the population of the Rheingau has risen sharply over the last decades. To meet the concurrent growing demand for potable water it has been necessary to increase the number of water production plants. The wellheads were either declared water protection areas or are currently in the declaration phase. Once this phase is completed, about 30 % of the land area of the Rheingau will be designated as water protection areas. The following water protection areas were already established by September

1, 2000 (personal message from the Regional Administrative Authority Darmstadt):

- I** Deep well **Abtswald** and **Klingelgraben**, subdistrict Johannisberg
- II** Deep well II (“**Vollradser Allee**“), municipality Oestrich-Winkel
- III** Deep well **Marienthal I**, subdistricts Geisenheim and Johannisberg
- IV** Deep well **Marienthal II** and **Grundscheidstollen** of the municipality Geisenheim, subdistricts Geisenheim, Johannisberg and Stephanshausen
- V** Deep well **Pfingstbachtal I** of the municipality Oestrich-Winkel, subdistrict Oestrich

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Deep well **Pfingstbachtal II** of the municipality Oestrich-Winkel, subdistrict Mittelheim

VI Well I–V of the municipality Eltville, community Erbach

The justification for designating water protection areas is based on the presence of nitrate and pesticide residues in the untreated groundwater of the water production plants (Staatsanzeiger für das Land Hessen, March 25, 1996). This poses a severe health threat especially for infants, since nitrates may cause the blood disease methemoglobinemia. In addition to this, there is some evidence indicating that the human body can convert

nitrates into carcinogenic nitrosamines ((TOUS-SAINTE 1989).

The legal limit for nitrate in potable water is 50 mg NO₃/l (EU Regulation 91/676/EU, dated 12. 12. 1991). This limit is exceeded by about 1/3 of the wells in the Rheingau. The legislative authorities assume that most nitrate contaminating the groundwater originates from fertilizers used in agriculture and viticulture. As a result, the water protection areas regulations are specifically concerned with controlling agricultural production with the aim of preventing groundwater nitrate contamination.

3. 3. Methods for designating water protection areas

Water protection areas are necessary to protect and safeguard groundwater sources for communal water supply (Section 19 article 1, No. 2 WHG). The management regulations for designating water protection areas are detailed in the government gazette for the state of Hesse published on March 25, 1996. Therefore, only the most important points will be described in the following section.

Any declaration of a water protection area must be preceded by a detailed soil survey of the potential area. The main criterion for the survey is the potential nitrate-leaching hazard. This can be approximately described by the following formula:

$$\text{pot. Leaching hazard} = \frac{\text{Amount of seepage water (mm)}}{\text{Field capacity (mm/dm)} \times \text{rooting zone (dm)}}$$

Since nitrates are not bound in the soil, they can be leached into the groundwater by water percolating through the vadose zone. In this context, seepage water is understood as the difference between precipitation and evapotranspiration. The discharge rate depends on the field capacity i.e. the amount of water a soil is capable of retaining in the root zone. Field capacity is determined by soil composition (e.g. soil type, lay-

ering, proportion of stones, organic matter content). Seepage water retention time varies with root zone depth. Long water retention times may also allow the roots to remove more nitrates. The actual nitrate transport rate depends on the nitrate leaching potential of the soil and short-term variable factors such as weather conditions or management practices.

A hydrogeological survey of water protection areas includes a classification of the soils into nitrate leaching risk classes. Nitrate leaching risk is divided into 5 classes ranging from very low to very high (Table 1).

A soil may be reclassified to a higher risk class under certain geological circumstances (Hes-

sisches Landesamt für Bodenforschung 1995). Because of the higher risk of nitrate leaching from agriculturally and viticulturally used soils, these are generally consigned to a higher risk class than that determined by their field capacity alone (terraplan 1999).

All regulations and bans issued in relation to agricultural practices within a water protection zone are based on the potential nitrate leaching

Tab. 1. Evaluation of the nitrate leaching risk based on field capacity of the rooting zone (FCR)

FCR [mm]	Annual available seepage water for groundwater recharge [mm]			
	≤ 100	101–200	201–300	≥ 300
≤ 130	4	5	5	5
131–260	4	4	4	4
261–390	3	3	3	3
391–520	2	2	2	2
≥ 521	1	1	2	1

risk of the location. These can vary between permitting normal agricultural practice with certain restrictions with respect to use of pesticides and other substances to a complete land use embargo. All regulations and bans are listed in the model water protection area act and should be adjusted according to the specific site conditions of the protection area (Staatsanzeiger für das Land Hessen, 25. März 1996).

The risk to the quality of the extracted water usually diminishes with increasing distance between the water production plant and the contamination source. This is why water protection areas are divided into different zones (Deutscher Verein von Gas- und Wasserfachmännern e.V. 1975).

4. The significance of water protection areas for wine growing

The water protection area act separately addresses viticultural management practices in water protection areas. The regulations govern the issues fertilization, soil amelioration, plant protection and documentation. These are general regulations and must be implemented equally for each wine-growing area.

The regulations concerning nitrate fertilization and soil preparation are especially strict in

These protection zones are differentiated as follows:

Zone III: Extended Protection Zone

Zone III is aimed at protecting the groundwater from extensive contamination especially by persistent or slowly degradable substances. Zone III extends from the outer boundary of the catchment area around the water production plant to the outer limits of Zone II. Zone III may be further subdivided into subzone IIIA and IIIB if required.

Zone II: Narrow Protection Zone

Zone II affords protection against contaminants and threats originating from human activities and facilities, which are extremely dangerous because of their close proximity to the water production plant. This zone encloses the area in which water requires 50 days to flow to the extraction area around the well of the water production plant.

Zone I: Extraction area

This zone is aimed at protecting the immediate area around the well from contaminants and other threats. Zone I extends to about 10 m around the well to the inner boundary of Zone II.

The management regulations defined in the water protection act vary in accordance with the protection zones. General regulations and bans apply for Zone III. These are augmented by additional regulations in Zone II. The extraction area is normally owned by the water works and is protected from unauthorized access by fences.

view of the high risk of nitrate influx into the groundwater. Thus mineral nitrogen application is restricted to 40 kg N/ha and year while organic nitrogen application may not exceed 140 kg N/ha for 3 years. Section 12 of the model water protection area act prohibits the application of nitrogen to topsoils with an organic matter content exceeding 2,5 % (Staatsanzeiger für das Land Hessen, 25. März 1996). Extensive cover

cropping is recommended to prevent nitrogen not taken up by the vine from leaching into the groundwater. The vine is perfectly capable of tolerating these conditions when site conditions and climate are optimal. However, the situation becomes critical in stress conditions.

The vineyards of the Rheingau vary considerably with respect to their organic matter content, potential mineralization of organic nitrogen and water balance. The competition for water and nutrients between vine and cover crop is intensified during particularly dry years or on soils with low organic matter contents. In extreme cases, the vine will then mobilize nutrients from the wood reserve. A series of stress situations during the lifetime of a vine may lead to premature ageing of the vineyard stock and therefore cause great economic losses.

Apart from the effects on the vegetative organs of the vine, suboptimal nutrient supply is also

suspected to have a detrimental effect on wine quality. In the dry years during the mid-nineties and following the bumper harvest of 1999 there was an increased occurrence of defects in the wine, which were described as untypical ageing off flavor. The main substance producing the defect was identified as 2-amino acetophenone (AAP) (MÜLLER 2000). Numerous studies have shown that the concentration of AAP increases with decreasing concentrations of yeast-available nitrogen in the grape juice (LÖHNERTZ 1997). The concentration of yeast available nitrogen is particularly affected by fertilization and water budget. There are no provisions in the general water protection act to react adequately to such stress situations. In the Rheingau, this has led to a search for solutions, which would facilitate quality orientated wine production while simultaneously affording the greatest possible protection of the groundwater.

5. Cooperation "Wine growing and groundwater protection"

Section 13 of the model groundwater protection area act states that farmers and winegrowers participating in a cooperation agreement with the communal water suppliers are not bound to the regulations of the act, but must instead comply with the conditions specified in the cooperation agreement. The agreement must be sanctioned by the regional water authority.

A cooperation agreement was developed for affected wine growing communities in the Rheingau between Wiesbaden and Lorchhausen. This specifies regulations for managing vineyards, taking into account local site conditions and land use. Under this agreement, winegrowers are obliged to obtain advice on adapting management practices in order to protect the groundwater. For example, the application of

fertilizer must take into account the vine requirements and the soil nutrient pool. Soil management practices and cover cropping systems can be adapted to ensure an adequate supply of nutrients to the vine. The agreement proscribes a complete winter plant cover to prevent the remaining nitrate in the soil from leaching into the groundwater after the vegetation period.

Winegrowers participating in this cooperation are obliged to apply the agreement regulations to all vineyards owned by their holding. This approach is expected to have a more positive long-term impact on groundwater than one where special management regulations only apply to areas within a water protection area.

375 Rheingau winegrowers have joined the cooperation "Winegrowing and Groundwater

Protection” since its formation in October 1998. Together they manage vineyards covering an area of 2080 ha. This means that 72 % of the land under vine between Wiesbaden and Lorchhausen is managed to safeguard groundwater quality.

An advisor is available to new members for the first three years after joining the cooperation. This service is supported by the Rheingau Winegrowers Association. The advice on ground-

water-optimized management is the result of a joint effort between the Geisenheim Research Centre, the Office for Viticulture in Eltville, the State Environmental Agency in Wiesbaden, and the local water works. Using the data and maps of the Vineyard Site Atlas it is possible to provide fertilization and management schemes optimally adjusted to local conditions.

6. Summary

The Rheingau is a favored residential area in close proximity to the Rhine-Main conurbation. This has led to a strong increase in population density in the last decades. Consequently, the number of water production plants has been increased to meet the rising demand for potable water. The catchment areas around these plants have been designated as water protection areas in order to protect the extracted raw water from detrimental effects. One of the main aims is to reduce the nitrate contamination of the wells. Once the designation phase has been completed, approximately 30 % of the land area of the Rheingau will lie within water protection areas.

The applicable regulations in water protection areas also include stringent requirements related to viticultural management practices. Strict compliance with these can have a negative effect on vine health and wine quality when site and climate conditions are unfavorable. This problem is resolved by the cooperation “Winegrowing and Groundwater Protection” permitted under Section 13 of the model groundwater protection area act. This provides regulations that take into account local site conditions and land use, thus promoting quality orientated wine production, while simultaneously affording the greatest possible degree of groundwater protection.

7. References

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